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# (12) UK Patent Application (19) GB (11) 2 296 256 (13) A

(43) Date of Publication 28.08.1996

<p>(21) Application No 9426084.3</p> <p>(22) Date of Filing 22.12.1994</p>	<p>(51) INT CL<sup>6</sup> C22C 23/02</p> <p>(52) UK CL (Edition O) C7A AB249 AB25Y AB250 AB26X AB261 AB263 AB265 AB267 AB269 AB27X AB271 AB289 AB309 AB319 AB32Y AB33X AB331 AB333 AB335 AB337 AB339 AB349 AB35X AB35Y AB389 AB39Y AB392 AB394 AB395 AB396 AB397 AB399 AB419 AB439 AB459 AB46Y AB48X AB481 AB483 AB485 AB487 AB489 AB519 AB539 AB549 AB559 AB610 AB613 AB614 AB619 AB62X AB621 AB624 AB627 AB630 AB635 AB66X AB661 AB663 AB665 AB667 AB669 AB670 AB675 AB682 AB684 AB686 AB688 AB70X AB702</p> <p>(56) Documents Cited GB 1427602 A GB 1196767 A GB 1163200 A GB 0690785 A EP 0419375 A EP 0414620 A WO 89/06154 A US 5073207 A</p> <p>(58) Field of Search UK CL (Edition N) C7A</p>
<p>(71) Applicant(s) Nissan Motor Company Limited  (Incorporated in Japan)  No.2, Takara-cho, Kanagawa-ku, Yokohama City, Kanagawa, Japan  Ube Industries Ltd  (Incorporated in Japan)  12-32 Nishimoto-cho 1-chome, Ube-shi, Yamaguchi Prefecture, Japan</p> <p>(72) Inventor(s) Kunihiko Makino Toshiro Kawata Kyosuke Kanemitsu Koji Watanabe</p> <p>(72) and (74) continued overleaf</p>	

## (54) Magnesium alloy

(57) An Mg-Al-RE alloy is disclosed wherein the amount of the rare earth component may be reduced while optimal tensile strength and durability are obtained. The alloy further includes a small calcium component. A high degree of creep resistance is obtained. Further copper and/or zinc may be introduced for providing favorable tensile characteristics. The compositional range is: 1.5 - 10% Al, less than 2% RE, 0.25 - 5.5% Ca, optionally 0.2 - 2.5% Cu and/or Zn, and balance Mg.

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

This print takes account of replacement documents submitted after the date of filing to enable the application to comply with the formal requirements of the Patents Rules 1990.

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**Masaji Matsunaga**  
**Mamoru Sayashi**

(74) Agent and/or Address for Service

**Marks & Clerk**  
**57-60 Lincoln's Inn Fields, LONDON, WC2A 3LS,**  
**United Kingdom**

FIG.1

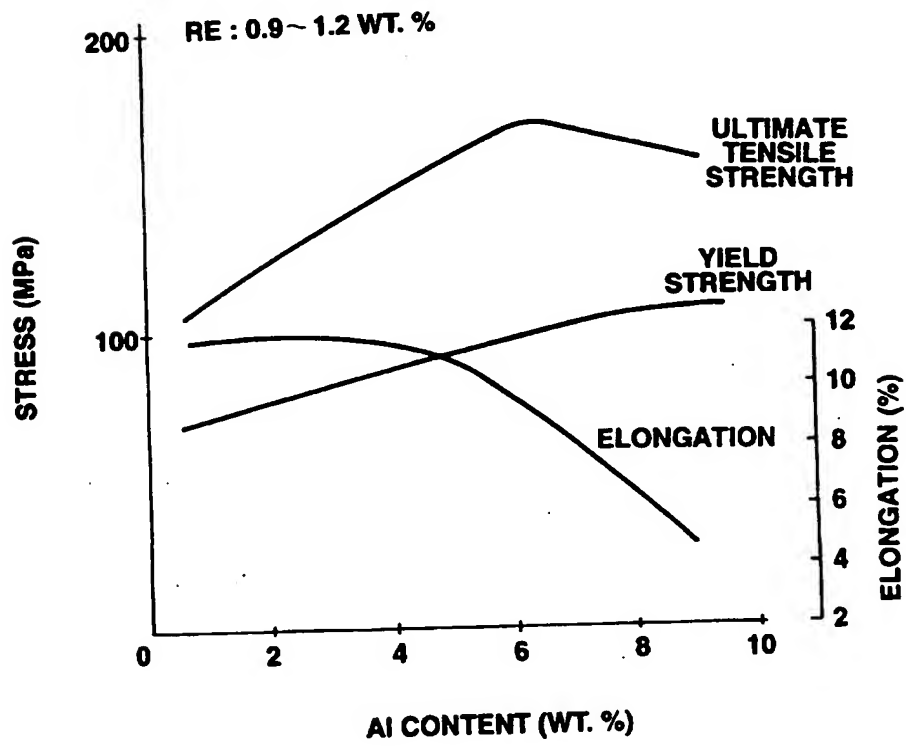


FIG.2

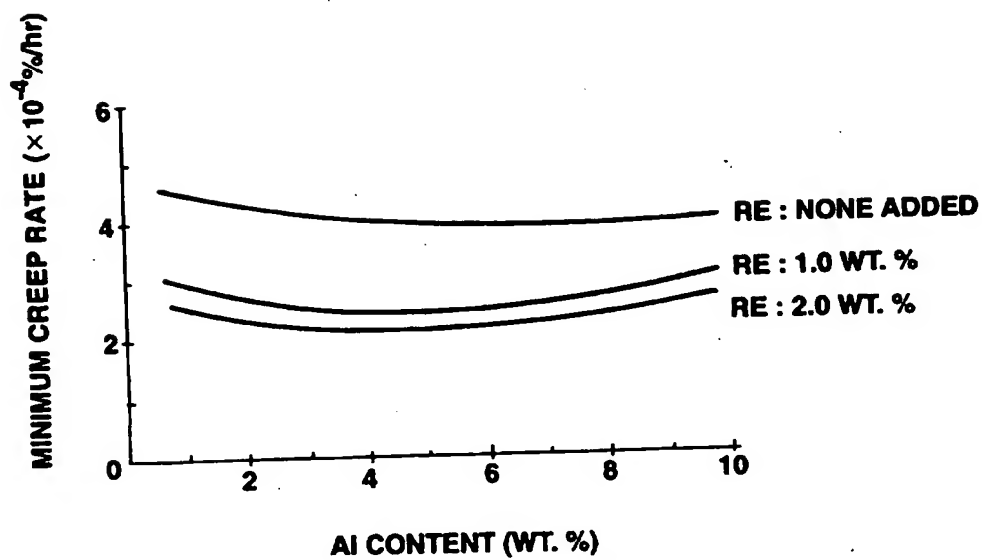
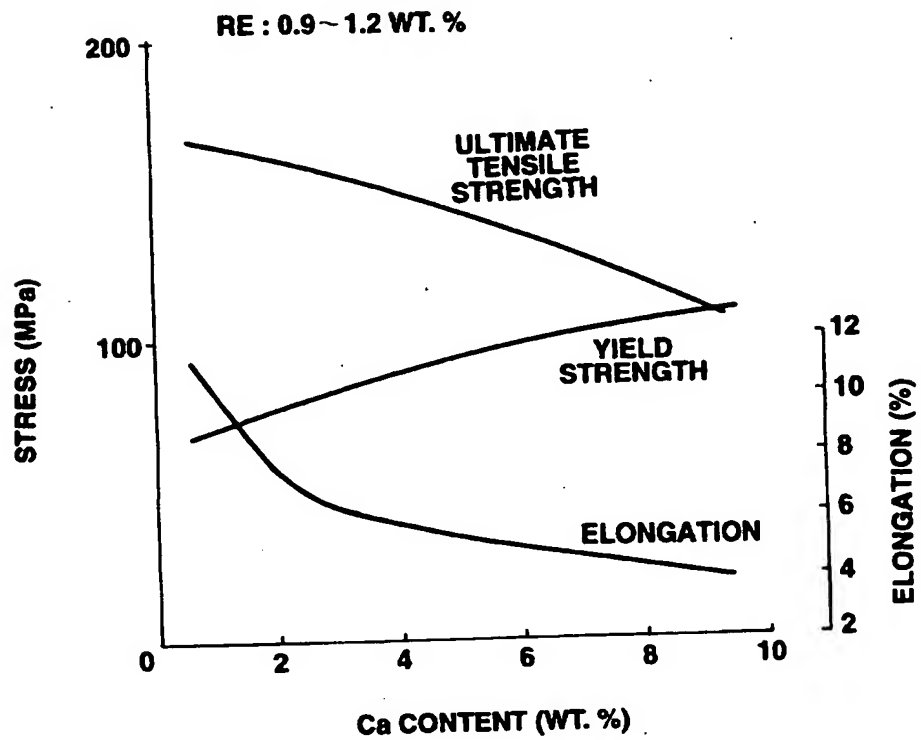
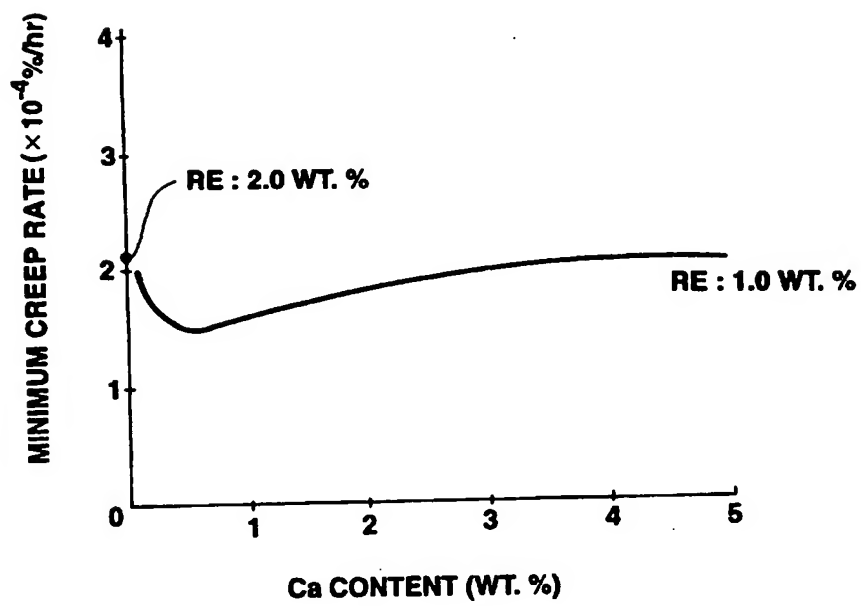


FIG.3



**FIG.4**

## MAGNESIUM ALLOY

The present invention relates generally to a magnesium alloy for industrial use.

Metallic alloys utilizing magnesium are widely used for automotive, electronic, aerospace, and various industrial applications. Particularly, such alloys are favorable which have high-temperature creep strength and which may be utilized in high-temperature environments.

Various magnesium alloys have been developed and registered such as JIS H 5203 (MC1 - MC10) and JIS H 5303 (MDC1A, MDC1B) magnesium alloys. For high temperature environments, AE42 having Mg-4%Al-2%RE developed by Dow Chemical is well known.

Such a heat-resistant magnesium alloy is difficult to utilize in die casting where fast cooling is employed after molding of a metal article.

Further, a rare earth (RE) component included in such alloys increases costs and high temperature creep resistance is reduced.

It would therefore be desirable to be able to overcome the drawbacks of the prior art.

It is an object of the present invention to provide an Mg-Al-RE magnesium alloy wherein RE is reduced and a small Ca component is introduced, while retaining a high degree of creep resistance and favorable bending characteristics.

Accordingly, the present invention provides a magnesium containing metallic alloy \_\_\_\_\_

material comprising: an aluminium (Al) component contained in a range of 1.5 - 10% by weight; a rare earth (RE) component contained in a range of less than 2% by weight; a calcium (Ca) component contained in a range of  
5 0.25 - 5.5% by weight; and wherein the remainder of the alloy is comprised of magnesium (Mg).

#### BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

Fig. 1 is a stress graph showing ultimate  
10 tensile strength, yield strength and elongation in relation to Al-RE content;

Fig. 2 is a graph illustrating minimum creep rate in relation to Al content for alloys having various levels of RE content;

15 Fig. 3 is a graph comparing stress and Ca content in relation to various characteristics in alloys containing RE in a given range; and

Fig. 4 is a graph showing minimum creep rate characteristics in Ca containing alloys in relation to a  
20 given amount of RE contained in the alloy.

#### DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the accompanying drawings, a preferred embodiment of the invention will be described hereinbelow in detail.

25 The present invention seeks to provide a Mg-Al-RE magnesium alloy wherein RE is reduced while a small Ca component is introduced, while retaining a high degree of creep resistance. According to the invention, additional Cu, Zn components may be introduced together or singly  
30 for providing favorable bending characteristics to the alloy material.

Various alloys have been formed according to generally known melting technique in a steel crucible having a nickel (Ni) component removed therefrom in an ambient atmosphere comprised of a gas such as SF<sub>6</sub>, CO<sub>2</sub> or



air.

Referring to Table 1, thirty-eight alloys have been utilized including nineteen embodiments of the alloy of the invention developed by the inventors through experimentation, and nineteen samples for comparison, including the above mentioned conventional alloy. The pieces were tested for various characteristics such as ultimate tensile strength, yield strength, elongation and minimum creep rate. Table 2 shows the effects of the various alloy compositions:

TABLE 1

SAMPLE TYPE	Al	CHEMICAL COMPONENTS BY WEIGHT % Mn RE Cs Cu Zn	Mg	COMMENTS
COMPARISON 1	2.0	0.39 - - -	REMAINDER	
COMPARISON 2	4.1	0.29 - - -	REMAINDER	
COMPARISON 3	9.5	0.25 - - -	REMAINDER	
COMPARISON 4	2.1	0.38 0.49 - -	REMAINDER	
COMPARISON 5	3.9	0.28 0.51 - -	REMAINDER	
COMPARISON 6	1.9	0.41 1.1 - -	REMAINDER	
COMPARISON 7	4.1	0.31 1.2 - -	REMAINDER	
COMPARISON 8	2.0	0.41 2.1 - -	REMAINDER	
EMBODIMENT 1	2.0	0.38 0.90 0.32 - -	REMAINDER	
EMBODIMENT 2	4.1	0.29 1.1 0.31 - -	REMAINDER	
EMBODIMENT 3	5.9	0.32 1.2 0.30 - -	REMAINDER	
EMBODIMENT 4	9.4	0.25 1.0 0.29 - -	REMAINDER	
EMBODIMENT 5	1.9	0.39 0.90 1.0 - -	REMAINDER	
EMBODIMENT 6	4.0	0.35 1.1 0.90 - -	REMAINDER	
EMBODIMENT 7	6.1	0.32 1.2 1.1 - -	REMAINDER	
EMBODIMENT 8	9.5	0.26 1.1 1.0 - -	REMAINDER	
EMBODIMENT 9	2.0	0.42 0.90 3.0 - -	REMAINDER	
EMBODIMENT 10	4.2	0.35 0.90 3.1 - -	REMAINDER	
EMBODIMENT 11	5.9	0.31 1.1 3.2 - -	REMAINDER	
EMBODIMENT 12	9.3	0.28 1.0 3.0 - -	REMAINDER	
COMPARISON 9	0.5	0.40 - - -	REMAINDER	
COMPARISON 10	1.1	0.42 - - -	REMAINDER	
COMPARISON 11	0.4	0.42 1.0 0.25 - -	REMAINDER	
COMPARISON 12	0.5	0.42 1.1 1.1 - -	REMAINDER	
COMPARISON 13	0.5	0.38 1.0 3.1 - -	REMAINDER	
COMPARISON 14	0.4	0.39 1.2 5.1 - -	REMAINDER	
EMBODIMENT 13	1.9	0.36 0.90 5.0 - -	REMAINDER	
EMBODIMENT 14	4.0	0.38 1.1 4.9 - -	REMAINDER	
EMBODIMENT 15	5.8	0.29 1.2 5.1 - -	REMAINDER	
EMBODIMENT 16	9.6	0.27 1.0 5.0 - -	REMAINDER	
COMPARISON 15	4.0	0.33 1.9 - - -	REMAINDER	AE42 Alloy
COMPARISON 16	3.9	0.34 2.3 0.25 - -	REMAINDER	
COMPARISON 17	4.0	0.35 2.4 1.1 - -	REMAINDER	
COMPARISON 18	4.1	0.32 2.3 3.1 - -	REMAINDER	
COMPARISON 19	4.0	0.33 2.3 5.1 - -	REMAINDER	
EMBODIMENT 17	4.0	0.34 1.1 0.2 0.5 -	REMAINDER	
EMBODIMENT 18	4.0	0.34 1.1 0.5 - 2.0	REMAINDER	
EMBODIMENT 19	4.1	0.32 1.2 0.2 0.5 0.5	REMAINDER	

TABLE 2

SAMPLE TYPE	BENDING STRENGTH (MPa)	DURABILITY (MPa)	STRETCH (%)	SMALLEST CREEP SPEED (10 <sup>-4</sup> %/hr.)
COMPARISON 1	75	38	9.2	5.96
COMPARISON 2	90	56	12.3	5.85
COMPARISON 3	115	72	10.5	5.82
COMPARISON 4	123	58	8.5	4.76
COMPARISON 5	143	85	11.3	4.63
COMPARISON 6	121	81	12.0	4.42
COMPARISON 7	125	92	11.6	4.15
COMPARISON 8	110	80	8.5	2.3
EMBODIMENT 1	160	65	13.1	1.63
EMBODIMENT 2	169	110	12.3	1.55
EMBODIMENT 3	195	84	13.2	1.95
EMBODIMENT 4	168	108	15.0	2.36
EMBODIMENT 5	135	65	8.5	2.26
EMBODIMENT 6	171	68	9.9	1.62
EMBODIMENT 7	162	59	10.5	1.79
EMBODIMENT 8	123	48	11.2	1.89
EMBODIMENT 9	128	116	4.2	1.75
EMBODIMENT10	159	81	5.9	1.89
EMBODIMENT11	156	92	4.5	1.72
EMBODIMENT12	150	110	2.9	1.94
COMPARISON 9	83	41	18.0	6.57
COMPARISON10	92	47	17.2	6.42
COMPARISON11	110	105	1.2	4.95
COMPARISON12	113	107	1.1	4.83
COMPARISON13	124	111	<1.0	4.80
COMPARISON14	131	115	<1.0	4.72
EMBODIMENT13	135	111	3.4	1.95
EMBODIMENT14	146	91	5.2	2.03
EMBODIMENT15	129	92	4.4	1.67
EMBODIMENT16	160	112	3.0	1.94
COMPARISON15	165	75	14.0	2.51
COMPARISON16	167	79	13.7	2.49
COMPARISON17	169	85	11.0	2.45
COMPARISON18	171	86	7.5	2.32
COMPARISON19	171	86	4.2	2.21
EMBODIMENT17	190	76	11.9	2.19
EMBODIMENT18	205	86	12.9	2.05
EMBODIMENT19	195	78	11.4	2.13

As may be seen from the Tables, embodiments 1 - 12 have favorable mechanical characteristics while RE is reduced compared with AE42 or the like, and high temperature creep strength is advantageously retained. Moreover, embodiments 13 - 15 include a Cu and/or Zn component, having ultimate tensile strength of about 200 MPa and yield strength of about 80 MPa. Also, a minimum creep rate of  $2.0 \times 10^{-4}\%$ /hr is obtained, while uniform temperature tensile characteristics are highly favorable.

It will be noted that high temperature creep strength is improved in comparison with AE42 and the other comparative examples, as shown in the tables.

While the present invention has been disclosed in terms of the preferred embodiment in order to facilitate better understanding thereof, it should be appreciated that the invention can be embodied in various ways without departing from the scope of the invention. Therefore, the invention should be understood to include all possible embodiments and modifications to the shown embodiments which can be embodied without departing from the scope of the invention as set forth in the appended claims.

Claims:-

1. A magnesium-containing metallic alloy material containing:  
an aluminium component , 1.5 to 10 wt.%;  
a rare earth component, less than 2 wt.%;  
a calcium component, 0.25 to 5.5 wt.%; and  
magnesium, the balance.
2. An alloy material as claimed in claim 1, containing a copper component and/or a zinc component in an amount of 0.2 to 2.5 wt.%.
3. A magnesium-containing metallic alloy material substantially as described with reference to any one of Embodiments 1 to 19.

<b>Patents Act 1977</b> <b>Examiner's report to the Comptroller under Section 17</b> <b>(The Search report)</b>	<b>Application number</b> <b>GB 9426064.3</b>
<b>Relevant Technical Fields</b>  (i) UK Cl (Ed.N)      C7A (ii) Int Cl (Ed.)	<b>Search Examiner</b> <b>R B LUCK</b>
<b>Databases (see below)</b> (i) UK Patent Office collections of GB, EP, WO and US patent specifications.  (ii)	<b>Date of completion of Search</b> <b>10 MARCH 1995#</b>
	<b>Documents considered relevant following a search in respect of Claims :-</b> <b>1-3</b>

**Categories of documents**

<b>X:</b>	Document indicating lack of novelty or of inventive step.	<b>P:</b>	Document published on or after the declared priority date but before the filing date of the present application.
<b>Y:</b>	Document indicating lack of inventive step if combined with one or more other documents of the same category.	<b>E:</b>	Patent document published on or after, but with priority date earlier than, the filing date of the present application.
<b>A:</b>	Document indicating technological background and/or state of the art.	<b>&amp;:</b>	Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages		Relevant to claim(s)
X	GB 1427602	(VARTA BATTERIE AG)	1 & 2
X	GB 1196767	(DOW CHEMICAL CO)	1 & 2
X	GB 1163200	(NASH HYDRO-ELEKTRISK ETC)	1 & 2
X	GB 690785	(DOW CHEMICAL CO) see especially Example 10 in Table	1 & 2
X	EP 0419375	(PECHINEY)	1 & 2
X	EP 0414620	(PECHINEY)	1 & 2
X	WO 89/08154	(PECHINEY)	1 & 2
X	US 5073207	(PECHINEY)	1 & 2

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